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Waste stabilization pond nutrient removal at the town of Shelburne.

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135 ST. CLAIR AVENUE WEST
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WASTE STABILIZATION POND NUTRIENT REMOVAL AT THE TOWN OF SHELBURNE

-- AN INTERIM REPORT --

RESEARCH BRANCH
MINISTRY OF THE ENVIRONMENT

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TOWN OF SHELBURNE

-- AN INTERIM REPORT --

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May, 1972

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SUMMARY

Field studies are being conducted by the Research Branch, Ministry of the Environment, on means of algal nutrient reduction in waste stabilization pond effluents.

The effluent from the west cell of the Shelburne ponds has been sprayed for three months on a 4 hectare (10 acre) tract of land with no adverse effects on the groundwater. Aluminum sulphate has been injected into the east influent at a dosage of 200 milligrams per liter for one turnover period and the effluent contians approximately 50 percent less phosphorus than the west control cell.

This interim report summarizes the operations to date.

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1. INTRODUCTION

The increased emphasis on reducing the nutrient loading, primarily phosphorus and nitorgen, from sewage treatment plants to their receiving streams has prompted various investigations into controlling the effluent nutrients from waste stabilization ponds (WSP).

Laboratory investigations conducted by the Research Branch, Ministry of the Environment (1) indicate that direct injection of chemical coagulants into the raw influent line can provide more than 80 percent reduction of total phosphorus in the effluent.

Jar test studies on raw sewage from the Town of Shelburne showed that aluminum sulphate (alum) was the optimum chemical for phosphorus precipitation. A facility for alum injection was put into operation at the influent to the east cell of the Shelburne WSP.

A literature review showed that spray disposal of sewage treatment plant effluent on suitable land improved the effluent percolate sufficiently so that it had no adverse effects when recharged to the groundwater reservoir. Effluent from the west control cell was sprayed on 4 hectare (10 acres) of land near the waste stabilization ponds.

This interim report summarizes the results of field studies from startup for one theoretical turnover period with alum injection and for a three month period of spray disposal. Alum injection is continuing throught the winter.

2. GENERAL

The Village of Shelburne (population 1500) is located at the junction of Highways 10 and 89 at the geographic centre of Dufferin County, Ontario. The village functions as a residential and farming community centre with no industry except for one feedmill.

The mean winter temperature of the Shelburne area is $-7^{O}C$ (19 to $20^{O}F$) and the mean summer temperature is $18^{O}C$ (64 to $65^{O}F$). There are about 130 frost-free days. Mean annual rainfall is 27 inches and snowfall is 100 inches (2).

Sewage treatment is provided by a 5.33 hectare (13.6 acre) continuous overflow waste stabilization pond consisting of two 2.66 ha (6.58 A) cells operated in parallel and designed to serve 1,350 people. Average flow to the WSP during the period covered by this report was 650 m^3 per day (0.143 MIGPD) at a 5-day Biochemical Oxygen Demand (BOD) loading of 23.9 kg/ha/day (21.3 lbs/A/day). Average total phosphorus concentration in the influent was 13 milligrams per liter (mg/l). Effluent from the WSP discharges to, and comprises the bulk of the flow of, a small tributary of the Boyne River which empties into Georgian Bay. Average effluent quality from the Shelburne WSP during the study period was 40 mg/l BOD.

The effluent from the west cell was sprayed on an area of unused land nearby and alum was injected into the influent of the east cell to reduce the phosphorus in the effluent. The west effluent was monitored as a control to compare differences in operation.

3. FIELD STUDIES

3.1 Chemical Injection into Waste Stabilization Pond Influent

3.1.1 Introduction

Soluble phosphorus may be retained in a waste stabilization pond by algal metabolism and sedimentation or through precipitation as calcium phosphate. Natural precipitation of calcium phosphate occurs when the pH of the pond contents is raised due to carbon dioxide utilization by the algae. These mechanisms have not been found effective for controlling the amount of phosphorus discharged in pond effluents (3).

Alum, ferric salts or lime (4) may be mixed with raw sewage, flocculated and precipitated to remove much of the BOD, suspended solids (SS) and phosphorus in the sludge. The clarified supernatant would then overflow to the WSP for further BOD and SS reduction and pH neutralization. This method would involve considerable modification of the influent structure with flocculation and sludge storage tanks; a means of sludge disposal would also be necessary. A more convenient means of phosphorus precipitation would be to inject the chemical coagulant directly into the influent line (1) where adequate mixing is available and the chemical sludge would settle on the WSP floor.

The latter method was incorporated at the influent to the east cell of the Shelburne WSP.

3.1.2 Sampling Program

An intensive monitoring program on the raw sewage influent and the effluents from both cells was carried on for a period of two months prior to chemical injection. Grab samples were usually taken for effluent quality while a 24 hour composite sampler was installed in the raw sewage wet well.

Samples of raw sewage (including some grab samples) were jar tested with alum, lime and ferric salts to determine optimum phosphorus removal. Supernatants from jars were decanted and submitted to the laboratories for analyses for:

5-day Biochemical Oxygen Demand (BOD)

Suspended Solids

pH

Total and Ortho Phosphorus

Further tests performed on the untreated raw sewage and effluent were for:

Nitrogen; Free Ammonia (NH_3), Total Kjeldahl, Nitrite (NO_2) and Nitrate (NO_3)

Chemical Oxygen Demand (COD)

Total Solids (TS)

Chloride (Cl)

Results of analyses of total phosphorus precipitated by chemical addition were calculated as a percentage of the control value. The relative frequency with which phosphorus removal could be obtained in fixed ranges between 60 and 99.9 percent as

a function of alum, lime and Fe(+3) concentration is shown in Table I.

Alum proved to be the best precipitant at an optimum concentration between 150 and 200 mg/l. From this information, it was decided to inject liquid alum into the influent to the east cell at Shelburne at a dosage of 200 milligrams alum per liter raw sewage.

Table 1

Relative Frequency of Percent Phosphorus Removal with:

Chemical	Chemical * Concentration	Less than 60	60 to 64.9	65 to 69.9	70 to 74.9	75 to 79.9	80 to 84.9	85 to 89.9	90 to 94.9	95 to 99.9
ALUM	25	.94	.06	--	--	--	--	--	--	--
	50	.82	.06	.06	.06	--	--	--	--	--
	75	.63	.06	.13	.06	.13	--	--	--	--
	100	.24	.24	.29	--	.12	.12	--	--	--
	125	.06	--	.06	.19	.19	.13	.13	.15	.06
	150	.06	--	--	--	.18	.12	.24	.35	.06
	175	--	--	.06	.06	.11	.11	.17	.28	.22
	200	--	.06	--	--	--	.11	.11	.22	.50
	225	--	--	--	--	.06	--	.17	.17	.61
	250	--	--	--	--	--	.06	.06	.17	.72
	275	--	--	--	--	--	.06	--	.22	.72
	300	--	--	--	--	--	--	.05	.26	.68
LIME	50	.93	--	.07	--	--	--	--	--	--
	100	.86	--	--	.07	--	.07	--	--	--
	150	.53	--	.13	.20	.07	--	--	.07	--
	200	.20	.07	.13	.07	.27	.07	.07	.07	.07
	250	.07	--	.13	.07	.20	.07	.13	.20	.13
	300	--	--	.07	--	.13	.20	.13	.20	.27
Fe^{+++}	20	1.0	--	--	--	--	--	--	--	--
	40	.89	--	--	.11	--	--	--	--	--
	60	.64	.18	.09	--	--	.09	--	--	--
	80	.45	.09	.09	.09	.09	.09	--	.09	--
	100	.27	--	.09	.09	.18	.09	.09	.09	.09
	120	.09	--	.18	--	.09	.27	--	.18	.18

* milligrams per liter

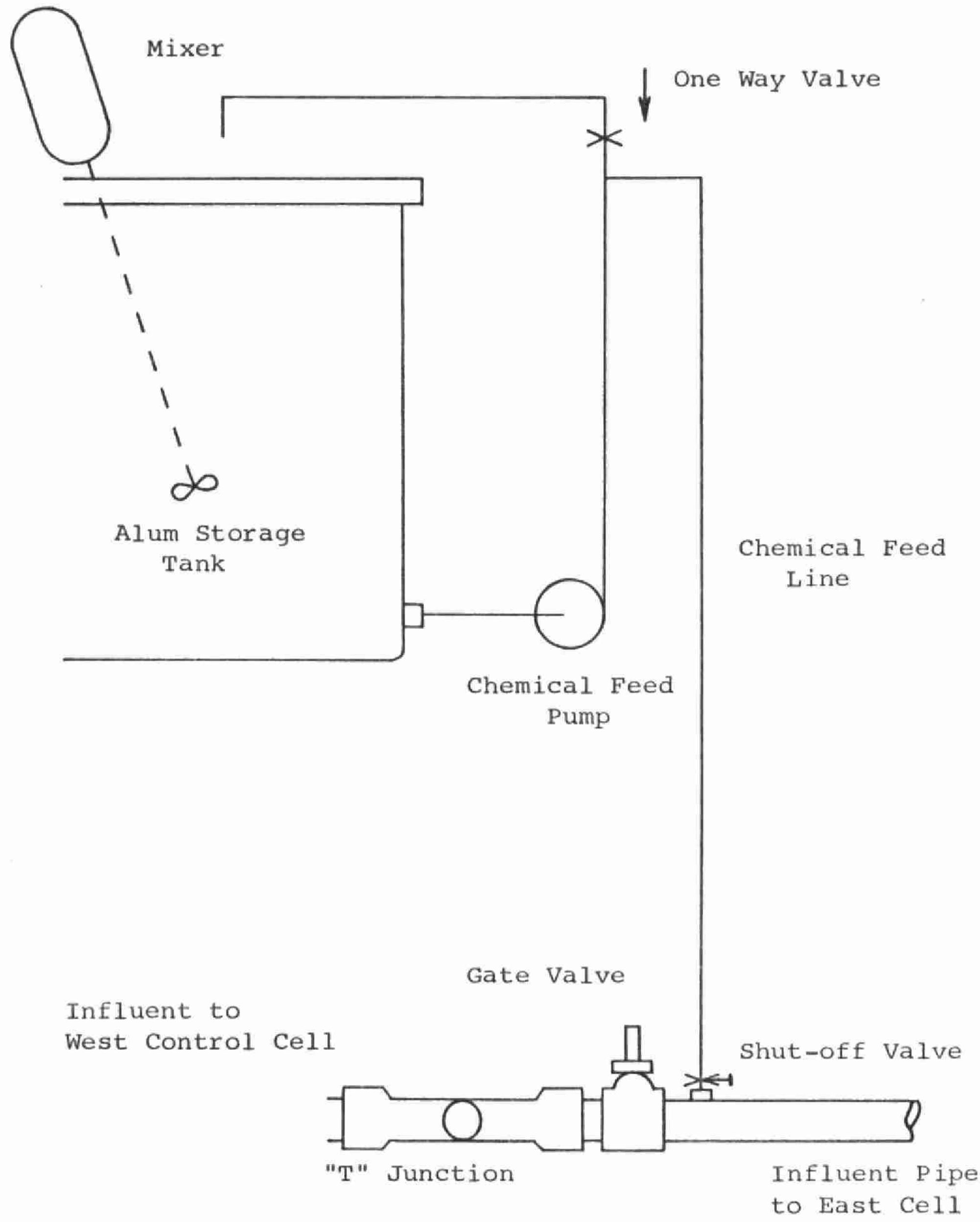
3.1.3 Field Installation

Sewage is pumped from a wet well by two 7.5 HP pumps (capacity 208 IGPM) which operate alternately or together (during periods of high flow) through a common 15 cm (6 inch) forcemain to a Tee junction. A 15 cm pipe leads off from each branch of the junction to the centers of the cells. Flow to each cell is controlled by a gate valve on either side of the Tee in a concrete valve chamber.

It was necessary to use a chemical feed pump rather than gravity flow because of the pressure head in the forcemain at the junction. Due to the irregularity of sewage flow, an electric diaphram pump connected to a timer was used to inject alum to the raw influent. The timer operated off the lower float switch in the wet well which controlled the sewage pumps. A 120 V, ac service line was installed from the sewage pumphouse to the centre berm beside the valve chamber. A semi-permanent storage building was erected at this location to house two 1.36 m^3 (300 gal.) storage tanks for the alum solution, feed pump, mixers and timers. A schematic drawing of the chemical feed system is shown in Fig. 1.

Alum solution was prepared by adding 500 pounds of alum to sufficient pond water to produce 100 gallons of slurry. This slurry was stirred continuously to keep undissolved alum in suspension.

A floatmeter and V-notch weir were installed in the effluent box of the east cell (that receiving chemical) to determine outflow rates.



Chemical Injection System into Shelburne WSP Influent

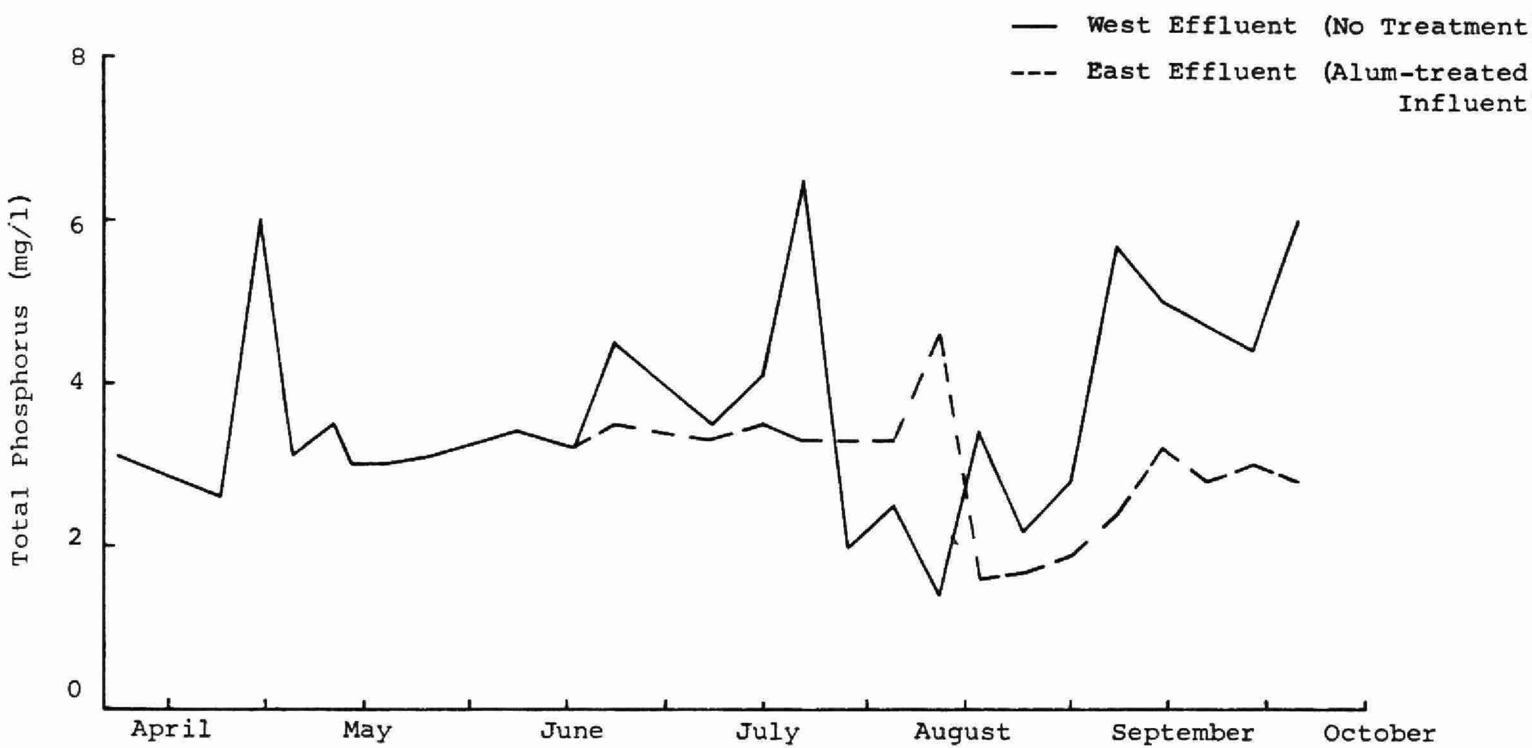
Figure 1	NGE	Nov. '71

3.1.4 Observations and Results

The major physical change observed in the east cell was a bloom of the blue-green algae Microcystis soon after chemical injection began. This strain dominated the cell throughout the summer, forming a thick mat in a corner depending on the prevailing wind direction. On August 23, alum feed to the raw sewage was reduced from 200 to 150 mg/l. Around mid-September, an abundance of Daphnia was observed throughout the treated cell. Concurrent with this phenomena was the disappearance of the blue-greens and sedimentation of the algae mat. Microscopic examination of the Daphnia revealed that most of the metabolized algae were of a green origin. Both cells presently have a similar green population with some Daphnia still in the treated cell. Causes of the blue-green bloom are under investigation.

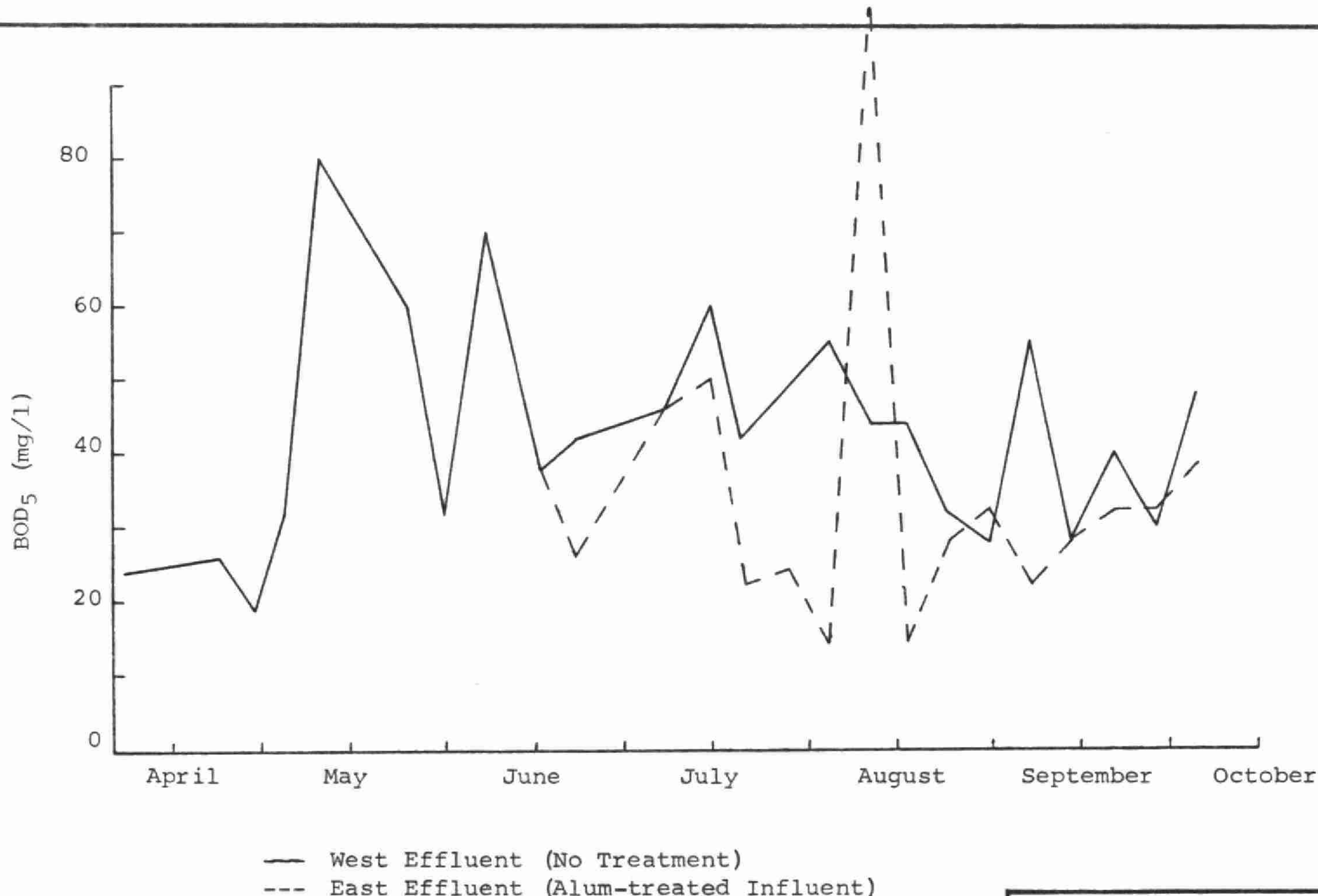
A comparison of total phosphorus values from the east (alum treated) and west (untreated) cell effluents is shown in Figure 2. The peak around the middle of August was due to heavy rainfall which dispersed the algae scum allowing it to flow from the cell.

BOD removal was better in the alum treated cell (see Fig. 3). The peak in August coincided with the breakup of the algae mat.



Effluent Phosphorus from Shelburne WSP vs. Time

Figure 2	NGE	Nov. '71



Effluent BOD from Shelburne WSP vs. Time

Figure 3	NGE	Nov. '71

A comparative summary of effluent quality from the treated and untreated cells in terms of suspended solids, nitrogen (free ammonia, total kjeldahl, nitrite and nitrate), chemical oxygen demand (COD) and pH is shown in Table 2. Differences between the two systems were noted using these parameters but no consistent pattern is apparent.

Nitrites were lower in the east effluent, indicating little aerobic oxidation by nitrifying bacteria.

TABLE 2 COMPARISON OF EFFLUENT QUALITY BETWEEN TREATED (TC) AND UNTREATED (UC) CELLS

Date	Suspended Solids		Free NH_3		Nitrogen Total Kjel		NO_2		NO_3		COD		pH	
	TC	UC	TC	UC	TC	UC	TC	UC	TC	UC	TC	UC	TC	UC
June 22	40	30	3.4	7.0	12	16	.02	.02	.1	.1	105	125	8.2	7.4
July 7	55	50	0.8	3.5	11	8.5	.03	.14	.1	.1		84		
15	90	90	0.5	2.9	8.5	11	.08	.27	.1	.1	185	275	8.8	
21	25	60	1.7	3.8	8.5	16	.02	.14	.1	.1	130	145		7.4
28	60	80	1.2	2.4	8.5	4.8	.06	.24	.1	.11	160		8.0	8.8
Aug. 4	25	80	3.0	2.9	9.0	9.0	.12	.32	.1	.1	130	120		
11	490	80	0.9	.07	28	5.0	.08	.17	.1	.2	600	140	8.1	8.1
17	40	75	0.3	1.4	8.0	12	.01	.02	.0	.1	115	175	9.2	8.4
24	70	60	2.3	.03	7.5	8.0	.05	.01	.1	.1		120	8.7	9.0
31	100	45	3.7	2.6	9.5	8.5	.06	.07	.1	.1	120	110	8.2	8.2
Sept. 7	35	105	5.4	3.9	12	16	.03	.04	.1	.1	130	170	8.0	7.8
14	40	40	6.2	4.0	18	16	.04	.08	.1	.1	135	110	8.3	8.4
21	45	45	6.0	5.4	13	10	.06	.08	.1	.1	130	110	8.4	8.0
28	60	60	8.8	4.2	14	8.5	.04	.19	.1	.2	140	105	7.8	8.1
Oct. 5	45	35	6.0	5.4	12	7.0	.17	.97	.2	.8	155	115	8.1	7.4

All Values in Milligrams per Liter except pH

3.1.5 Discussion

At present, the difference in effluent phosphorus levels between the alum fed and the untreated cells is not appreciable. However, laboratory investigations showed that at least 1 1/2 to 2 turnover periods were necessary before differences were significant. Differences in BOD are not remarkable since alum has little effect on soluble BOD.

The production of blue-greens in the east cell was not anticipated. Blue-greens bloom preferentially in slightly basic water whereas the addition of alum to the influent tended to keep the pH around neutral. Blue-greens are reported to have toxic effects on animals when ingested and their discharge to receiving streams is undesireable.

Alum injection into the east cell influent is continuing throughout the winter to determine the effectiveness of chemical treatment without the benefits of photosynthesis and aerobic conditions. Investigations to determine the cause of the blue-green blooms are continuing.

3.2 EFFLUENT SPRAY DISPOSAL ON LAND

3.2.1 Introduction

Land disposal of effluent as a means of avoiding discharge into public water courses is not a new concept in Ontario. Papers presented during several Ontario Industrial Waste Conferences describe the disposal on land of dairy, tannery, cannery and pulp mill wastes. They also discuss problems encountered and, in most cases, the success of the operation. (5)

Land disposal of effluent from domestic waste stabilization ponds is in operation on a small scale in resort areas. Ponds are filled in the summer and the effluent is sprayed in the fall or in the following spring. Land is usually available as golf courses or treed areas. Sites are at safe distances from populated areas, so there is no direct health hazard.

In the case of land disposal of effluent the soil, in combination with the vegetation, provides treatment of the wastewater through evapotranspiration, adsorption, chemical precipitation, ionic exchange, biochemical transformation and biological adsorption, with the treated effluent recharged to the groundwater reservoir. (6) The main object of land disposal of effluent is to apply the maximum amount of water a given soil can absorb without causing clogging of the soil, surface run-off, contamination of the groundwater or damage to the vegetation. (7)

Land disposal may give problems. Some consitituents present in the wastewater can damage the soil and vegetation. Although copper, zinc and other heavy metals are adsorbed by soils, their salts in certain concentrations are toxic to plants. Chlorides, which are not absorbed by soils, and also nitrogen, as nitrate, can percolate into the groundwater.

Waste stabilization ponds used in connection with a spray irrigation system are being designed as sewage treatment facilities for several small communities in Ontario. To date the allowable rate for spraying has been 56 m^3 per ha per day (5000 IG per acre per day), a fairly arbitrary rate. Since the wastewater flow is a continuous one, the waste stabilization ponds become also storage reservoirs from which the effluent is sprayed on suitable days of the year. An important factor will be the land necessary for spraying. Land and spray equipment cost will be high when the allowed application rate of effluent is low.

The spray irrigation study at Shelburne, initiated to investigate the particular problems within that area, will also provide information on general questions regarding spray irrigation.

The purpose of the study is therefore manifold:

a) To establish criteria for maximum allowable spraying rates of effluent (m^3 per ha per day or cm per week).

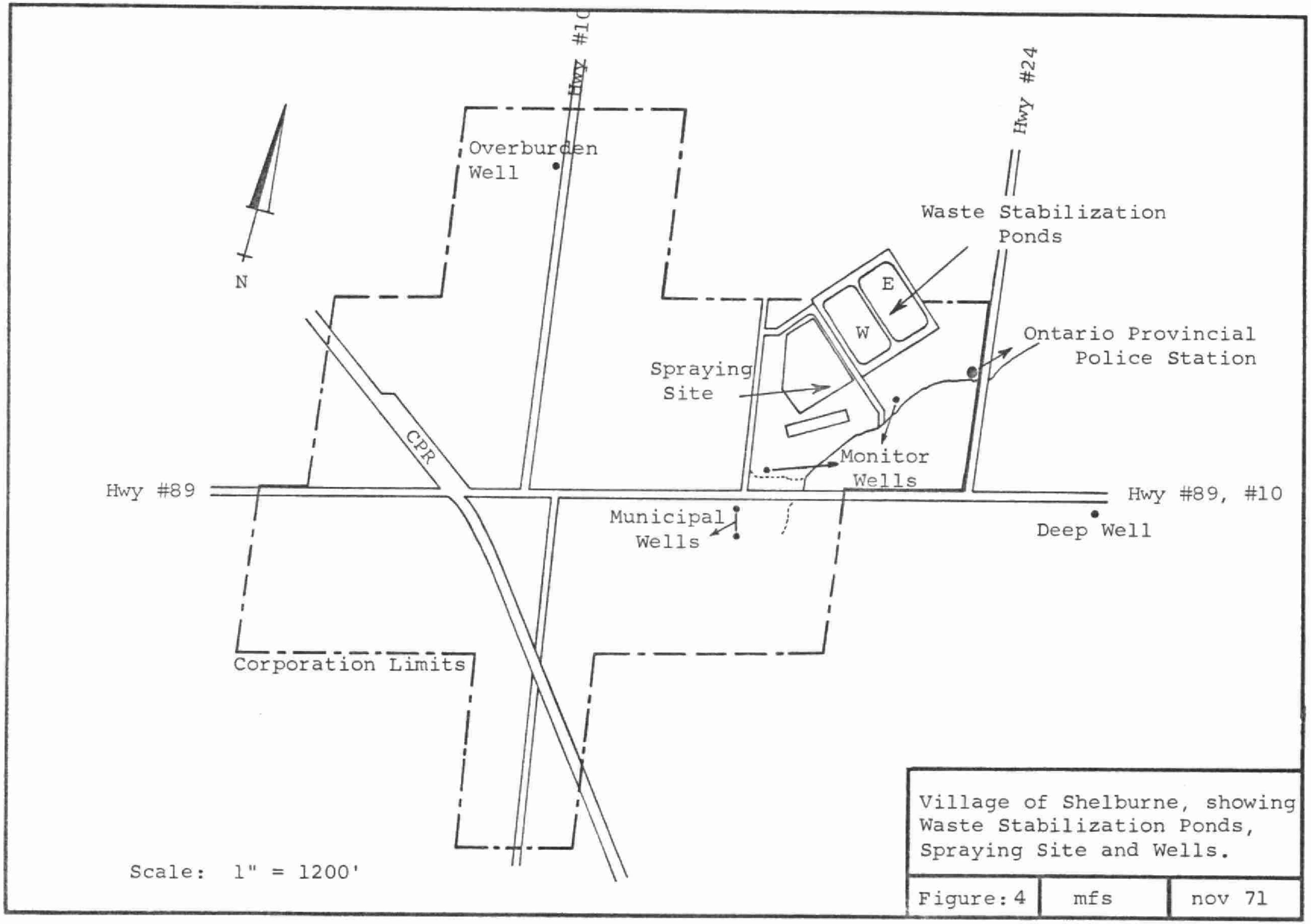
b) To gather information on the treatment capacity of the soil, and the possible contamination of groundwater.

c) To evaluate the suitability of different crops.

d) To investigate any physical side-effects as a result of spraying of waste stabilization pond effluent.

The location of the waste stabilization ponds (east and west cells) and the spraying site is shown in Figure 4. The land was selected because of its convenient location and suitable soil. It is municipally owned land and permission was given by Council to use it for the purpose of the study. The area is approximately 4 ha (10 acres) of which 3.2 ha (8 acres) is land with a twitch grass vegetation and 0.8 ha (2 acres) is a treed area with heavy groundcover.

The wastewater is from domestic waste only. The effluent from the west cell is sprayed. Averages for chemical constituents in the effluent are given in Table 3. (Samples are taken over the period March - October 1971). The average daily inflow into the west cell was 273 m^3 (60,000 I Gal) during August, September and October 1971.



Village of Shelburne, showing Waste Stabilization Ponds, Spraying Site and Wells.

Figure: 4	mfs	nov 71

TABLE 3 — CHEMICAL CONSTITUENTS IN THE EFFLUENT OF THE WEST WASTE STABILIZATION POND.
(Averages March - October, 1971)
(Figures in mg/litre except for pH)

BOD	42
COD	130
Phosphorus as P	
Total	3.8
Soluble	2.3
Nitrogen as N	
Free Ammonia	3.6
Total Kjeldahl	10.7
Nitrate	.24
Nitrite	1.8
Solids	
Total	600
Suspended	60
Dissolved	540
Calcium, as Ca	65
Magnesium, as Mg	25
Sodium, as Na	53
Potassium, as K	9.5
Chlorides, as Cl	72
Sulphates, as SO_4	46
Alkalinity, as $CaCO_3$	270
Hardness, as $CaCO_3$	270
Iron, as Fe	0.40
Manganese, as Mn	0.12
pH	7.4 - 10.6

3.2.2 Preliminary Investigation

The Water Quantity Branch of the Ministry of the Environment undertook a study of the hydrogeology in the Shelburne area. Physiographically, Shelburne is located on the Dundalk Till Plain, surrounded by a complex of glacial spill-ways, fluted till plains, kames and till moraines. The topography is generally gently undulating. Two types of soil are predominant: a) Honeywood soils, well drained, that have developed on wind-deposited silt loam or fine sandy loam materials underlain by calcareous loam till; b) Tuscola silt loam, imperfectly drained, developed from calcarious water-lain fine sands and silts.

The bedrock in the area is grey and blue-grey medium crystalline dolomite of the Amabel Group of formations. It is highly fractured and easily recharged by percolating groundwater. The bedrock in this area forms one of the best aquifers in Ontario.

The overburden at the spraying site is approximately 13 meters deep (40 ft) and consists of a sandy till.

The direction of the surface drainage in the area is towards the northeast and east. There are a few overburden wells in the area but most of the wells are bedrock wells.

The municipal wells, two bedrock wells, are approximately 360 m (1200 ft) from the spraying site. A pumping test was carried out to determine the influence of the municipal wells on the aquifer in the vicinity of the spray area, using the monitoring facilities installed on and around the site. The pumping test showed that the natural gradient of the bedrock peizometric

surface is towards the municipal wells as a result of continuous use of the municipal wells. The overburden piezometric surface is sloped away from the municipal wells. No hydraulic connection between the overburden and bedrock aquifer was observed.

The soils at the spraying site were mapped for suitability by Professor L.R. Webber of the University of Guelph. Soil in the grassed area consists of a well drained, fine, sandy loam with a moderate permeability of 1.5 - 4.0 cm per hour (0.6 - 1.5 inches per hour). Maximum water retained under field conditions for the first 1.2 m (4 ft) equals approximately 23 cm (9 inches). The land itself is slightly undulating and the groundwater table is approximately 1.5 m - 2.4 m (5 - 8 ft) below the surface.

The soil in the treed area has poorer draining characteristics and the water table was approximately 0.5 m (1.7 ft) below the surface. The area was used for a low rate of application to evaluate the effects of spraying on the trees, mainly cedar trees, and the groundcover.

Table 4 presents averages for precipitation and evaporation in the Shelburne area, derived from information gathered at the Redickville station of the Atmospheric Environment Service and the climatic maps of Canada.

Table 4

Averages of Precipitation and Evaporation for the months of the year in the Shelburne area.

Month	Precipitation		Evaporation	
	cm	in	cm	in
January	8.96	3.53	0	0
February	7.80	3.07	0	0
March	9.01	3.55	0	0
April	7.75	3.05	5	2
May	7.60	2.99	11	4.5
June	7.46	2.94	14	5.5
July	7.44	2.93	15	6
August	8.33	3.28	11	4.5
September	7.46	2.94	8	3
October	7.57	2.98	5	2
November	9.65	3.80	2	1
December	8.35	3.29	0	0

Precipitation figures from Redickville Station
Evaporation figures from climatic maps of Canada

3.2.3 Design of the Spray System and Spraying Program

The spray system was designed to make use of the most suitable parts of the available land. For the purpose of the study the grassland was divided in two parts each of 1.6 ha (4 acres) approximately. (A, B, figure 5) The third part is the treed area. (C)

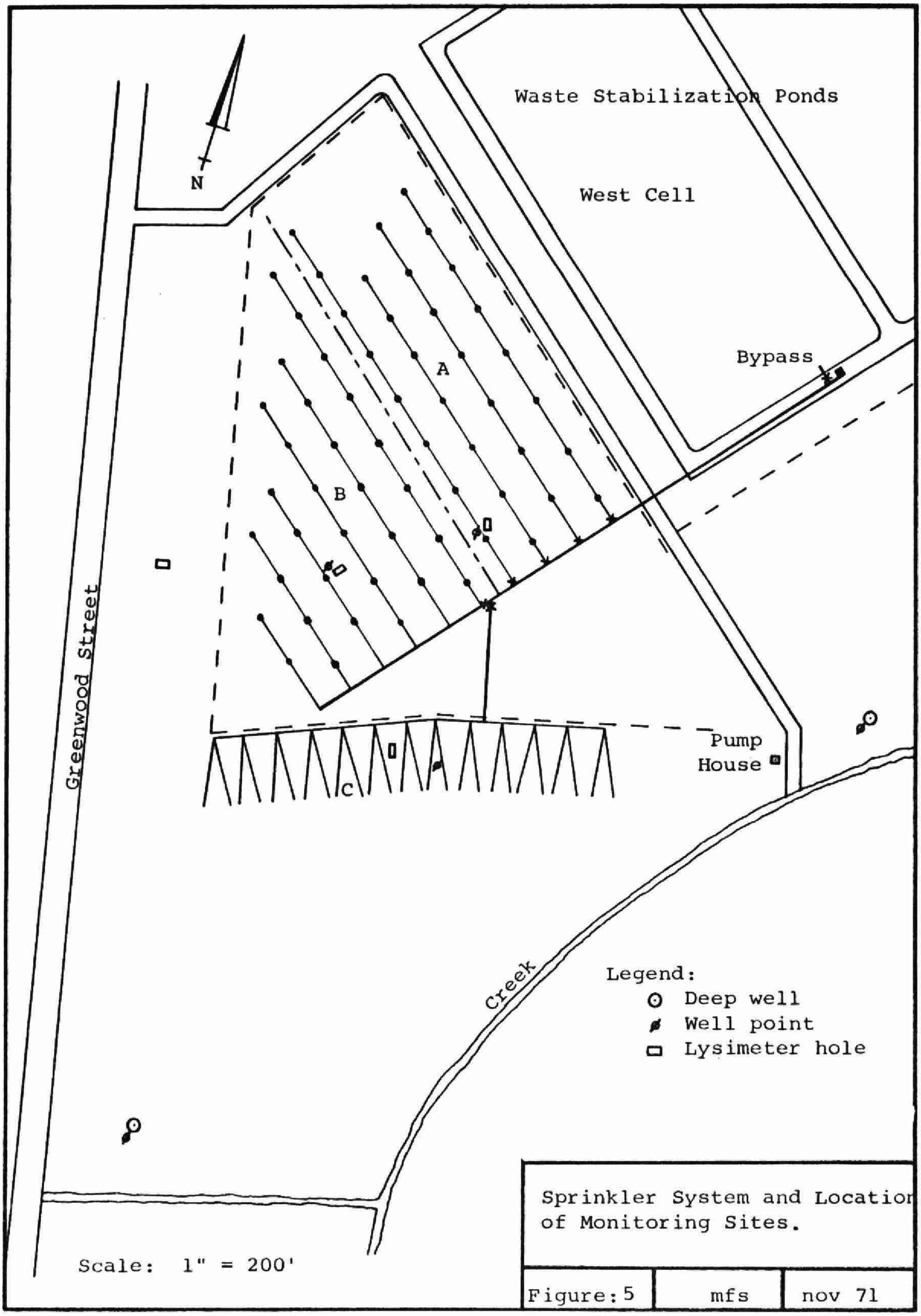
The main pipe to the spraying site consists of 10 cm diameter (4") aluminum pipe. In each of the grassed areas 30 commercial sprinklers were installed connected to polyethylene 5 cm diameter (2") laterals. The system was assembled at the site. In the treed area garden-soaking hoses with holes punched at regular intervals were used. They are easily placed between the trees. The outline of the spraying installation is given in Figure 5.

An electric centrifugal pump with a capacity of 910 liters per minute (200 IGPM) at 45 m (150 ft) of head, pumps the effluent from the cell towards the land. The effluent is not screened but pumped as it is from the outlet manhole of the cell.

The theoretical spraying program was planned as follows:

Area A, grasscover, 10 cm (4") per week
Area B, grasscover, 5 cm (2") per week
Area C, treed, approx. 2.5 cm (1") per week

No one area was to be sprayed on consecutive days. Allowance must be made for rainfall and for unexpected circumstances,



Sprinkler System and Location of Monitoring Sites.

Figure: 5	mfs	nov 71

since damage to the spraying site is not allowed. If the spraying program can be carried out as planned it would be possible to divert 2730 m^3 (600,000 IG) of effluent each week. This means that the land would receive in one week of regular spraying: 114 kg (250 lbs) BOD, 10 kg (22 lbs) Phosphorus; 34 kg (74 lbs) Nitrogen; 195 kg (430 lbs) Chlorides.

It was decided to leave the existing twitch grass cover on the land, since there was not sufficient time available to start a new crop. The grass was cut four weeks before spraying started.

3.2.4 Monitor Program

An extensive monitor program was started to check for possible contamination of groundwater and damage to the soil as as result of spraying.

The main concern is the municipal water supply and some wells in the vicinity of the waste stabilization ponds and spraying site. Since the beginning of March 1971, a regular sampling program has been carried out. The effluent, several sections of the creek into which the effluent previously discharged, and wells are sampled and tested for chemical constituents, bacteriological quality and presence of virus.

For the monitor program two bedrock wells were installed, one on the south side of the waste stabilization ponds and one between the municipal wells and the spraying site. The pumping test showed that the latter well is affected by a drawdown in the municipal wells.

Five well points were installed to measure the depth of the groundwater table below the surface. They also provide sampling points for groundwater. One is placed in each of the sections to be sprayed and one near each monitor bedrock well. To evaluate the efficacy of the soil in removing chemical constituents, such as nitrogen and phosphorus present in the effluent, lysimeters were installed. Lysimeters, at different depths, collect percolating groundwater for sampling.

Each grassed area has four lysimeters at 15 cm, 30 cm, 60 cm, and 120 cm (6", 1', 2' and 3') below the ground surface. The treed area has a surface lysimeter at 15 cm (6").

A set of control lysimeters was installed west of the site. The locations of wells, well points and lysimeters are shown in Figure 5.

During the spraying program the sampling of effluent, creek and wells will be continued. When possible, effluent, all wells, wellpoints, lysimeters, and the creek will be sampled weekly and analysed for several chemical constituents, bacteriological quality and presence of virus.

Chemical tests for nitrogen, phosphorus, solids, chloride, potassium, sodium, pH, were done routinely. When deemed necessary, extra analyses were done on an irregular basis. One house well, selected for monitoring in the vicinity, already showed signs of contamination, possibly as a result of septic tank drainage before spraying started and was therefore abandoned.

Since little information is available on migration of viral pathogens in soils and groundwaters, this aspect is receiving much attention. The effluent is checked weekly for the presence of salmonella and enteric virus. Samples from wells and ground water are tested for virus contamination using E. Coli B bacteriophage as an indicator. They are also tested for salmonella and enteric virus. Prior to spraying, all monitoring wells were negative for the viral pathogens mentioned above. Soil samples and vegetation cuts were also submitted for bacteriological analysis.

A raingauge was installed on the site to measure the rainfall in the area. The temperature of the water in the pond is measured daily and recorded.Evaporation data are supplied by the Atmospheric Environment Service for the Elora Station, not far from Shelburne.

3.2.5 Operation and Observations

Spraying started on July 28, 1971. At that time all the monitoring equipment had been installed and provided some background data.

Problems were encountered with the polyethylene piping, which is sensitive to temperature changes. The problems were overcome by allowing the pipe to move freely. Pressure checks at the sprinklers showed an average pressure of 3.8 to 4.2 kg/cm^2 (55 to 60 psi) for all the lines except the one farthest removed from the ponds. This means that the sprinklers were operating at their maximum capacity of 44 liters per minute. (7 IGPM).

When the treed area was sprayed the flow was about half of the normal capacity of the pump. Part of the flow was bypassed back into the pond.

Table 5 presents total amount of precipitation in the different areas due to rainfall and spraying for the months of August and September. It also gives the evaporation data for these months. Although evaporation data, collected for open water, are not truly representative for the evapotranspiration rate of the grasses, they give an indication of potential evapotranspiration. The table does show that a considerable amount of the precipitation did evaporate. It was not always possible to carry out the spraying program as planned due to heavy rainfall on some days.

TABLE 5

SUMMARY OF TOTAL PRECIPITATION AND EVAPORATION

FOR THE THREE AREAS SPRAYED

AREA	MONTH	RAINFALL		SPRAYED		TOTAL PREC.		EVAPORATION	
		cm	in	cm	in	cm	in	cm	in
A	August	6.58	2.59	25.82	10.14	32.40	12.73	16.35	6.44
	September	2.87	1.13	38.63	15.21	41.50	16.34	9.00	3.52
B	August	6.58	2.59	22.12	8.71	28.70	11.30	16.35	6.44
	September	2.87	1.13	14.13	7.54	22.00	8.67	9.00	3.52
C	August	6.58	2.59	7.12	2.80	13.70	5.39	16.35	6.44
	September	2.87	1.13	9.63	3.80	12.50	4.93	9.00	3.52

The level of the west cell was about 30 cm (1 ft) lower than the east cell by the beginning of October. During August and September the soil absorbed the effluent very well in all three areas. There were no signs of ponding or clogging. The grass grew prosperously in the sprayed area.

At the beginning of October the soil appeared very wet in some parts of the high rate area and the spraying rate for this area was reduced to 5 cm per week to avoid ponding on the ground surface. The influence of evaporation became less important during October. The groundwater table has risen slightly in the treed area, but the other areas show no change in groundwater level.

Monitor, municipal, and house wells showed no significant variations in any of the chemical constituents. None showed contamination with coliforms and all were negative for the tests of viral pathogens. All well points have yielded good groundwater samples with no significant change in chemical quality. A few fecal coliforms were noticed in the wellpoint samples from the treed and the low rate area in the middle of October. To date no viral pathogens, present in the effluent, have been found in wellpoint samples. The spraying has had no obvious effect on trees or the ground cover. Grass cuts show a high coliform count. Soil samples from areas exposed to spraying were negative for the bacteriophage analysis.

The lysimeters have not all yielded sufficient percolate for groundwater samples. In the high rate area only from the surface lysimeter and in the low rate, from the surface and deepest lysimeter, can suitable samples be obtained. The control lysimeters

have not received enough rainfall for regular sampling. No samples from the lysimeter in the treed area could be obtained due to high groundwater level.

The surface lysimeters in both grassed areas show 95% removal of total phosphorus present in the effluent. Total Kjeldahl nitrogen is 80% removed and nitrites 99%. No increase in nitrates has been observed. There has been a slight increase in chlorides and sodium, most likely due to a concentration as a result of evaporation. Potassium is slightly decreased. It should be noted that percolate samples result from rainfall as well as spraying of effluent.

There have been no complaints about odours as a result of spraying. When a strong wind is in the direction of the Ontario Provincial Police Station (the prevailing wind direction) dampness is noticed on cars parked at the station and sometimes a mist is felt by staff.

An inspection of the pipes after 2 1/2 months of operation showed a greasy coating on the inside. There have been no problems with clogging of pipes or sprinklers.

3.2.6 Discussion

At this time (end of October, 1971) land disposal of waste stabilization pond effluent in Shelburne has been in operation for three months. This relatively short time of operation does not permit a complete evaluation of all possibilities and problems involved with spray irrigation. No definite conclusions can be drawn and recommendation for future sites can not be made. The following remarks are appropriate:

a) During the warm summer months a high rate of application, (e.g. 10 cm per week) seems feasible for a soil with a moderate permeability and good grass cover. This high rate cannot be maintained during colder months.

b) The percent removal of nutrients in the first 15 cms of the soil is very high and does not seem to depend on rate of application. The figures compare with data for removals presented in other studies (6, 8).

c) After three months of operation there are no adverse effects on soil, groundwater and vegetation. An increase in concentration of chlorides and sodium has been observed in percolate samples. No traces of viral contamination of groundwater have been found.

d) Carrying of spray by strong winds can become a nuisance. Spraying on windy days should be avoided, unless appropriate measures are taken on the spraying site such as planting of trees.

e) A spray program needs to be flexible to allow for rainfall. Soils must have recovery time. Spraying equipment and spraying sites require continuous attention. Regular surveys of the sprayed land must be made to notice any undesirable situation, such as ponding or surface runoff.

3.2.7 Continuation of the Program

The weather was favourable for spraying during the month of October. Spraying was continued although at lower rates of application than originally outlined, and it is hoped to carry out the program for some time in November.

It will not be possible to spray during the winter. The pipes are not self-draining and manpower for daily attention is not available. The pond will discharge again into the creek, but a permanent solution for the ponds will hopefully be found next year.

During the winter a sampling program will be carried out to trace possible after-effects of the spraying. Spraying will start again in the spring. The land sections will be sprayed with the same or possibly higher rate. It is proposed to cultivate crops in small plots on the sprayed land. The monitoring system, particularly the lysimeters, will need some expansion and improvement.

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